By this amendment, the original claims, which were translations of the original German claims, have been canceled. New claims 25 to 53 have been submitted. The new claims are drafted in more clear terms, using US patent law conventions. The claims are slightly narrower in scope from the original claims. Some new claims setting forth subject matter described in the specification but not claimed initially are also submitted.

The original "use" claims have been canceled. New method claims 51-54 are directed to a method for in-vivo scanning of teeth of a patient, a principal use of the invention described in the specification. New claims 25-58 are submitted to more completely claim the embodiment in which radiation in two different bands of the spectrum is used to illuminate the object, as set forth in the text of the specification on pages 7 and 8.

No new matter has been introduced into the application by virtue of the replacement of the claims with new claims 25-58. Withdrawal of the § 112 rejection is requested.

Anticipation rejection

The Examiner rejected claims 1-21 as anticipated by Tsai, U.S. Patent 5,309,243. The applicants will treat this rejection as pertaining to all of the new claims. As explained below, the present invention defines novel subject matter over Tsai.

Briefly, by way of review, the present invention relates to a method and apparatus for scanning an object. The illustrated embodiment describes a method and scanner for obtaining three-dimensional image information regarding the surface of the teeth, but of course the method and scanner can be used for other types of objects. When generating images of three-dimensional surfaces, problems arise in that the surface geometry or

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composition may be such that obtaining images of all the surfaces with proper contrast is difficult. This is particularly the case with objects with complex three-dimensional geometry, such as teeth, which may have fillings or crowns with a high degree of reflectivity while adjacent areas may have low reflectivity.

As described in the specification, e.g., at pages 5-8, the invention works on the principle of illumination of the object with at two different light sources, and, in the preferred embodiment, controlling the amount of beam energy that impinges on a two-dimensional electronic image converter (e.g., CCD array). The amount of beam energy that impinges on the image converter can be controlled by changing the illumination intensity of the light sources, using a high intensity light source and a low intensity light source, or by placing optical elements such as shutters between the light sources and the object or between the object and the image converter. Two images are obtained in succession, one at a lower amount of received beam energy and the other at a higher amount of beam energy.

The low–lit images (i.e., images with low amount of received beam energy) will image parts of the surface of the object with a high degree of reflection satisfactorily, while parts of the surface with a low degree of reflection are imaged only dimly, and thus without a substantial data content. The strongly lit images (i.e., the images with the high amount of received beam energy) allow the weakly reflecting surface portions to be imaged sufficiently brightly, and with a high data content, while the strongly reflecting surfaces are extremely bright and appear saturated. The two images can be partially or completely combined by means of electronic data processing using suitable algorithms to obtain a composite image with sufficient contrast in all the areas of interest.

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Furthermore, information as to the surface configuration of the object can be obtained by using two light sources operating at different portions of the electromagnetic spectrum, as described at pages 7-8 and claimed in new claims 55-58.

Claim 25 is as follows:

25. A method for scanning an object with a scanner having at least one two dimensional electronic image converter, at least one optical element imaging the object on the electronic image converter, and first and second beam sources for illuminating the object, comprising the steps of:

a) illuminating said object with said first beam source at a first illumination level and substantially simultaneously obtaining a first image of the object with the electronic image converter at a first level of received beam energy;
b) illuminating said object with said second beam source and substantially simultaneously obtaining a second image of said object with said electronic image converter at a second level of received beam energy different from said first level;
c) wherein said steps a) and–b) are performed in succession to thereby obtain two consecutive images of the object with the electronic image converter at different levels of received beam energy.

Independent claim 36 is similar to claim 25, but recites that there are two different electronic image converters, one for the first image and the other for the second image. The invention of claim 36 is useful for the situation in which visible spectrum is used for the first image and infrared or ultraviolet is used for the second image. Independent method claim 55 is similar to claim 36, but omits any reference to the levels of received beam energy and instead specifically recites the two portions of the electromagnetic spectrum.

Independent apparatus claim 39 is similar in scope to claim 25. Independent method claim 50 is narrower in scope than claim 25 in that it is directed to a method of scanning teeth, and recites the method steps performed in claim 25 in the context of scanning anatomical structures in the oral cavity of a human or animal patient.

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Turning to Tsai, this reference is directed to an exposure control method for electronic imaging systems, such as still and motion video cameras and film scanners. The goal of Tsai is provide a technique for exposure control that enables use of lower cost, lower resolution eight bit electronic devices to capture contrast information. Tsai generates a plurality of digitized images including a plurality of pixels at 5 different exposure levels (col. 1 lines 34-45), and describes a data processing algorithm to substitute or replace underexposed or overexposed pixels. Col 2, lines 8-44. In the Figure 1 embodiment, Tsai controls the exposure level entirely by operation of a shutter 125 and/or aperture 115 in the optical path between the objective lens 110 and the electronic image sensor 120. See col. 4, lines 43-54. There is no illumination used. In the film scanner embodiment of Figure 2, Tsai uses only a single variable light source 410, and accomplishes exposure control by operation of the light source 410.

In the present invention, all of the independent claims require illumination of the object using two different light sources. For example, claims 25 and 39 requires a scanner having first and second beam sources and the steps of "illuminating said object with said first beam source . . ." and "illuminating said object with said second beam source . . . ." Thus, the independent claims are not anticipated by Tsai.

Furthermore claim 26 recites that an optical means is placed in the path between at least one of the beam sources and the object which influences the effective amount of beam energy impinging on the detector. This subject matter is not described in Tsai.

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Claim 29 recites that image data from the first and second images is processed by image processing algorithms to generate three-dimensional information as to the object. This is also not disclosed in Tsai. Claims 30 and 31 recite features relating to the synchronism of the illumination of the object by the two beam sources with the refresh rate of the electronic image converter. This is also not disclosed in Tsai. Claims 33, 34 and 42 relate to using a high intensity flash lamp for at least one of the illumination sources. Tsai merely describes a "variable light source" 410 (col. 5 lines 56-60), and does not contemplate a flash lamp.

As to claim 36, this claim recites not only two illumination sources, but also two separate electronic image converters. Dependent claims 37 and 38 recite the use of one beam source being a visible spectrum source and the other source being an infra-red or ultraviolet radiation source. This subject matter is not described in Tsai.

As to claim 50 and claims dependent therefrom, these claims relate to in-vivo scanning of the teeth of a patient, and recite structure and method steps similar to that found in claims 25 and 39. This subject matter is not described in Tsai.

Finally, claim 55 recites the use of two beam sources operating in different portions of the electromagnetic spectrum. This subject matter is also not found in Tsai.

Accordingly, the anticipation rejection should be withdrawn.

Obviousness Rejection

The Examiner rejected claims 22-24 as obvious over Tsai in view of Brandestini et al. U.S. Patent 4,837,732. The rejection of claims 22-24 is moot in view of the cancellation of

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such claims, but the applicants will treat the rejection as to all the new claims in the interest of completeness.

Tsai, as noted above, either controls exposure level by operation of shutter or an aperture in the path between the object and the image converter, or by operation of a single variable light source. Brandestini, on the other hand, describes a scan head having a single LED light source 2 and a ruling 4 that projects an alternating masked and unmasked (black and white) pattern onto the tooth (col. 4 lines 25-40, text bridging columns 8 and 9). Captured images are stored as two quadrature patterns in two different memory banks A and B. The data is transformed using a mathematical process described in columns 10 and 11 and new data is contained in the memory banks: one bank containing 3D depth information and the other containing data of the contrast of the backscattered pattern for each pixel. Col. 7 lines 11-28.

Brandestini's use of imaging processing algorithms in conjunction with the black and white projections, to obtain 3D and contrast data, is done with a single LED illumination source. Brandestini has no need for, and thus is silent on, a scan head in which two different illumination sources are used, as claimed. A person skilled in the art would not be motivated to combine Brandestini with Tsai to produce the claimed invention because Tsai and Brandestini use completely different techniques for exposure control and acquiring contrast information. At any event, even assuming the references were combined, which applicant submits is improper, the result would not be a method and scanner in which two different illumination sources are used in the manner claimed.

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Reconsideration of the application and allowance of the claims is respectfully requested.

Respectfully submitted,

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CERTIFICATE OF MAILING

The undersigned hereby certifies that this Amendment A is being deposited as first class mail, postage prepaid, in an envelope addressed to Assistant Commissioner for Patents, Box Fee Amendment, Washington DC 20231 on this 18 th day of January, 2001.

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